Research on Rradiochemistry and Geochemistry at KIT-INE, Germany, in Support of the Nuclear Waste Disposal Safety Case

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1. Research profile of KIT-INE

The demand of a science based and transparent procedure to select a repository site providing safety over a time period of 1 million years represents an unique and fascinating challenge.

Research and development at the Institute for Nuclear Waste Disposal (INE) at the Karlsruhe Institute of Technology (KIT) are conducted as an integral part of the national provident research in the frame of the Helmholtz Association of German research centers (HGF) research program NUSAFE. INE develops and operates unique radiochemical and analytical infrastructures for the investigation of radionuclide materials. With about 100 employees KIT-INE is the largest institute inside the HGF, covering research for various aspects of nuclear waste disposal and nuclear waste management.

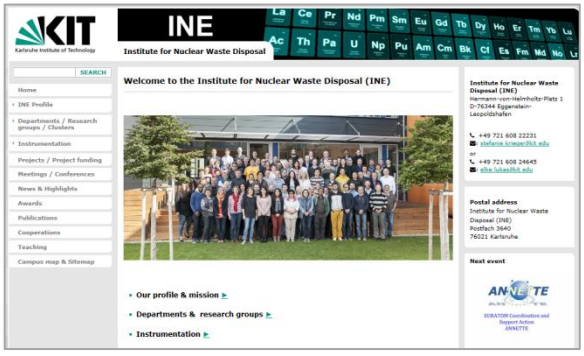

Fig. 1. The website www.ine.kit.edu, offers detailed information on KIT-INE, including the comprehensive Annual Reports issued by the institute.

2. Selected Research Highlights

2.1 Aquatic chemistry and thermodynamics

KIT-INE is providing comprehensive scientific information on key aspects controlling radionuclide behavior in solution, i.e. solubility phenomena, redox processes, complexation reactions with inorganic and organic ligands or ion-interaction processes. Recent work on fundamental actinide chemistry includes Pu(VI) solubility and speciation studies, with a strong focus on the chemical characteristics of solubility limiting solid phases. Similarities of Pu(VI) phases and related Np phases in NaCl and $CaCl_2$ media are given. In addition to the Th(IV) system studied at KIT-INE previously, new studies on mixed hydroxo-carbonate complexation have investigated tetravalent Uranium, Neptunium and Plutonium. A full set up data and thermodynamic descriptions are now available in the An(IV)-OH-CO_3 series, also extending to Tc(IV). A focus of recent R&D at KIT-INE is centered on actinide-organics complexation reactions. Complexation and solubility increase of Pu(III) and Pu(IV) due to interaction with isosaccharinic acid was extensively investigated. The topic actinide-organic-interactions will be further developed within a current research proposal coordinated by KIT-INE within a joint European research initiative. Research on aquatic radionuclide chemistry uses synergies with the INE operated EXAFS beamlines at KARA (formerly ANKA).

2.2 Radionuclide sorption

The interaction of radionuclides with relevant mineral surfaces is a key activity at KIT-INE followed over several decades. Studies are presently focused on coupled redox-surface reactions, the influence of organics on sorption, and assessing the influence of high ionic strength conditions on sorption processes. An example will be given on the sorption of europium in presence of gluconate or citrate onto clay minerals. As part of a German research consortium, KIT-INE will increase research activities in underground laboratories, investigating several aspects of radionuclide retention and transport at the Mont Terri site in Switzerland. Within the EC funded CEBAMA project (www.cebama.eu) coordinated by KIT-INE, research on processes at the interphases between cement-based-materials and other components is performed in view of predicting radionuclide mobility. An example on Beryllium sorption on cementitious materials investigated by KIT-INE will be given.

2.3 Radionuclide retention on Fe corrosion phases

The retention on radionuclides on Fe phases, forming in the near field of the waste due to canister corrosion processes, is a growing research field at KIT-INE. Work is performed on identifying relevant secondary Fe mineral phases forming under different chemical boundary conditions, and investigating radionuclide retention and incorporation on these solids. Work is combining wet chemistry experiment and advanced spectroscopy available at KIT-INE.

2.4 Coordination chemistry

Coordination chemistry is focusing on liquid-liquid extraction processing using N-Donor ligands, with the aim of deriving fundamental understanding of processes controlling the selectivity of these ligands toward trivalent Actinides and Lanthanides. Classical extraction studies are combined with spectroscopy and modern quantum-chemical calculations at KIT-INE which promise an innovative predictive assessment of ligand properties in extraction studies. Fundamental studies are likewise performed in order to derive improved process understanding on the interaction of radionuclides with the human Transferrin protein and other related bio-molecules.

2.5 Thermodynamic Data and Databases

Selected estimation methods for thermodynamic data, which may allow to derive a workable thermodynamic database for aquatic systems at elevated temperature conditions (< 100°C), are being developed within the ThermAc project coordinated by KIT-INE. Systematic estimation approaches are combined with experimental investigations of selected key systems, thus allowing for a critical assessment of the estimation approaches. Activities within the NEA-TDB are continuing at KIT-INE as a main contribution to this field, including researchers co-chairing the new Update Volume and a report on Pitzer modelling. The German THEREDA database project, where KIT-INE is responsible for actinide and radionuclide data, is likewise further developed.

3. Summary

Within this contribution, an overview of recent research performed in the radiochemistry division at KIT-INE is given. Examples are taken from R&D activities performed within the HGF NUSAFE programme, but also from studies performed within collaborations on the national and international level. It finally may contribute to increased interaction and exchange of KIT-INE with Korean research groups interested in nuclear waste disposal topics.